SETTING PERFORMANCE CODE OBJECTIVES[†]
HOW DO WE DECIDE WHAT PERFORMANCE THE CODES INTEND?

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ABSTRACT

There is a worldwide movement toward the replacement of prescriptive codes with those based on performance against a set of clear and quantifiable objectives. This has sparked an important discussion of just what are appropriate objectives for society to demand of its built environment. Building codes have evolved well beyond their traditional roles of assuring the public health and welfare by incorporating requirements addressing social issues such as conservation and protection of heritage. In the fire codes, debate is raging over whether people should be required to protect their own property from fire, and whether society can afford to protect all of the occupants and the fire service throughout any incident. Thus far, the discussion has been limited to identifying objectives, and has not yet turned to performance levels; a step that must be taken before performance codes can be implemented. Performance levels cannot simply be derived from current codes. Defining code objectives and performance levels in the U.S. presents a special challenge since these public policy issues must be debated by several model code groups, fifty state legislatures, and countless local bodies. NIST's role in the process is to provide the technical basis for the evaluation of performance against objectives, but not in setting the objectives nor their levels. However, since the code objectives in part determine the need for specific performance evaluation methods, NIST has an interest in facilitating the reaching of consensus on these difficult issues related to its role in the application of technology to maintaining U.S. competitiveness in world markets.

1. BACKGROUND

Much of the world is engaged in a process to replace prescriptive building and fire codes with ones based on performance. That is, instead of *prescribing* the precise number and arrangement of protective measures which are required, the *performance* of the overall system against a specified set of objectives is presented. Canada has proposed to refer to these as objective-based codes because, in fact it is the objectives that are stated and not the performance per se.

There is a general consensus on the form of performance codes[1]. These include first, a set of clear, quantitative objectives and second, a means to establish whether those objectives have been met. A performance code will usually also include "deemed to satisfy" provisions which codify approaches which experience has shown to provide acceptable solutions, such as the dimensions of egress stairs. These performance codes further include "Approved Documents" which are intended to catalog acceptable solutions for use in cases where a performance analysis is not needed. The first such approved document is generally the old prescriptive code.

The purpose of this paper is to raise some important issues regarding this process and to begin a discussion of some important questions. These include:

1. What are appropriate objectives for building and fire codes, and at what level of detail must they be specified?

2. Who makes these policy decisions for the public and how do they become mandated and enforced? and,

3. How do we begin the process of determining the objectives appropriate for U.S. codes?

[†]InterFlam '96, Seventh International Fire Science and Engineering Conference, March 26-28, Cambridge, England, 555-561 pp, Interscience Communications, London, 1996.

2.BUILDING CODES

As many others have pointed out, the Code of Hammurabi (attributed to King Hammurabi of Babylonia who reigned from 1955 B.C. to 1913 B.C.) is credited as the first building code and was a performance code which included requirements such as:

> *In the case of the collapse of a defective building, the architect is to be put to death if the owner is killed by accident; and the architect's son if the son of the owner loses his life.*

The objective is clear as is the penalty for failure, but the means to assess compliance is to wait for the failure -- clearly unacceptable in modern society. Further, it is unclear what is the intent with regard to the deaths of occupants other than the owner.

Modern building codes have evolved well beyond their traditional areas of public health and welfare. Frequently building codes are vehicles for the implementation of environmental policy by incorporating requirements for energy and water conservation. Some address noise pollution with requirements for the acoustic transmission properties of partitions. Others address the preservation of historical structures and still others include quality of life issues such as prohibiting the mixture of certain building uses (i.e., zoning requirements). The latest in this growing list involve electromagnetic fields from electrical equipment and "sick building syndrome."

A number of groups, individually or through international committees such as the International Commission on Building Standards and Research (CIB) TG11 are seeking to develop appropriate objectives for building codes which are compatible with the transition to performance codes. This debate is focused on identifying the needs of society from the perspective of the designers, builders, owners, and users of buildings as a key to setting the code's objectives. The process has demonstrated that there are significant cultural differences among countries which impact such decisions, so no clear answers have yet surfaced.

3. STRUCTURAL CODES

The structural portions of building codes underwent a transition to a performance format about a decade ago. The objective of a structural code is unquestionable -- the building must continue to stand under any foreseeable circumstance. The process followed by the structural engineering profession is of general interest in the move to performance codes. A technique of structural calculations was developed in which the profession had confidence. These calculations were then used to "back out" the design loads implied by the prescriptive code, and inconsistencies identified by this process were resolved. Finally, safety factors were specified both by inflating these loads and derating material strengths to arrive at a solution which is always on the high side of the uncertainty band.

Of more interest to the topic of this paper is the debate over how to set appropriate wind, snow, and seismic loads for given zones, as these are statistically distributed. Do you design to the 10 year, 50 year, or 100 year event? The decision was made for the codes to design to the 50 year level, understanding the likelihood that this level will be exceeded (2% per year, 64% over the 50 years) and using a safety factor of 1.3. This represents a policy decision made by the engineers and confirmed by the legislators who adopted the code into law. Current discussions center on whether the entire building needs to resist the 50 year wind or if roofs and windows can be designed for less if the structure survives.

4. FIRE CODES

4.1 GENERAL OBJECTIVES

Several fire code groups are debating the list of objectives which should be included. A general discussion of the history of fire code objectives is included in reference 1. This paper and another by Bukowski & Tanaka[2] lead to the general objectives of:

- Prevent the fire or retard its growth and spread,
- Protect building occupants from the fire effects,
- Minimize the impact of fire, and
- Support fire service operations.

However, even objectives such as these, which most recognize as the fundamental goals of traditional fire codes are being debated in the process of developing performance codes. Some of these debates have become quite heated. For example, in New Zealand it was decided that protection of the property of the person who has the fire is a matter between that person and their insurance company, and is not something to be regulated in the code[3]. This decision was not supported by the insurance industry as it meant that they had to establish their own regulation and enforcement. It has further been suggested that the impact of fire losses on the economy (e.g., loss of jobs, inconvenience to society) makes protection of such property an issue for the codes.

Even more controversial is the questioning of code requirements for the safety and integrity of a building after the evacuation of all occupants. It has been suggested that the code should only require the building to remain safe until the occupants are out, since society demands fire safety for the "public" which does not include firefighters . This debate in Canada has not been well received by the fire service there. Most countries have taken the position that protection of firefighters and support of their suppression operations are explicitly included in the list of objectives contained in the code.

4.2 DETAILED OBJECTIVES

With the continued evolution of performance codes, and especially as the means for evaluating compliance with the performance objectives have tended toward risk assessment methods, it is becoming apparent that the level of detail at which these objectives are being specified is insufficient. For example, if the analysis is limited to a specific set of design scenarios (i.e., a *hazard* analysis), the goal that there should be no fatalities among building occupants is reasonable. However, the goal of eliminating all risk to life from fire is not. Further, setting a goal with respect to life loss says nothing of the acceptability of injury. In the World Trade Center bombing incident, litigation has been filed seeking compensation for the emotional trauma of being exposed to smoke during the evacuation, even though no physical injury was sustained!

This raises many questions of who makes the public policy decisions for society, how the policy is established, and what society is willing to accept in terms of both losses and cost. While the general objectives as discussed in the previous section may be sufficient for policy makers, engineers and enforcers need much more detailed objectives in order to properly judge the ability of specific designs to meet those goals across the spectrum of possible fire scenarios. If there is one thing which we should have learned from the history of fire losses is that the greatest losses have occurred in the cases where multiple things have gone wrong.

In Boston, the Office of the Fire Marshal[4] established a set of objectives for fire hazard assessments for multi-family residential occupancies performed in support of requests for waivers of the prescriptive requirements of the code. These would certainly be suitable as objectives of a performance based code, and provide an additional level of detail necessary for engineering analysis. They are:

- Limit the probability of fatalities or major injuries to only those occupants intimate with the fire ignition.
- Limit the probability of minor injuries to only those in the dwelling unit of origin.
- No occupant outside of the dwelling unit of origin should be exposed to the products of combustion in a manner that causes any injury.
- Limit the probability of flame damage to the dwelling unit of fire origin (this includes taking into account the possibility of flame extension up the exterior of the building).
- Limit the probability of reaching hazardous levels of smoke and toxic gases to the dwelling unit of fire origin before safe egress time is allowed. At no time during the incident should the smoke conditions in any compartment, including the compartment of origin, endanger persons in those compartments or prevent egress through those compartments.

- C Limit the incident to one manageable by the Boston Fire Department without major commitment of resources or excessive danger to firefighters during all phases of Fire Department operation, i.e., search and rescue, evacuation, and extinguishment.

While attorneys would argue that these statements are still not sufficiently precise for regulation, they begin to give the engineer and architect the guidance needed to arrive at a specific design. Note as well that these objectives incorporate the expectations of the fire service with regard to the conditions which they will face when they respond.

5. PUBLIC POLICY

5.1 WHO MAKES THE DECISIONS?

Whether building or fire code, who makes the technical decisions for the public? Many countries operate under national codes promulgated by the government (e.g., Japan, England and Wales) and some produce a national model code with local concurrence (e.g., Australia, Canada). In the U.S., the several model code organizations are private and the regulatory authority rests wholly within the States. Yet in each case, the technical issues regarding appropriate levels of safety required are debated and set by the codes committees with the eventual concurrence of the public authority. In each case, a process exists by which local modifications can be made to the model code, but these are generally done to address a local issue or to make a requirement of the model code more stringent. Seldom are local modifications made which relax requirements below the minimums established in the model code.

This means that the debate over which objectives are appropriate would begin in the model codes process. The codes committees could debate the issues and produce a "sense of the committee" which could be taken to the oversight committee[††] which serves as the gatekeeper to each of the model codes. From there, the list could be debated by the state Fire Marshals through the National Association of State Fire Marshals (NASFM) and Fire Marshals Association of North America (FMANA) and organizations like National Conference of States for Building Codes and Standards (NCSBCS) as a means to determine its acceptability to regulators.

5.2 HOW DOES THE POLICY BECOME MANDATED?

The current system is that the codes and standards are set by the model codes groups and they are adopted into law by the state and local jurisdictions. This would not change. The legislators who adopt the codes and standards have powers delegated to them by the Constitution, and are elected to office to act for the public good. However, these officials are accountable to the public and will need a means to explain the impact of these new regulations. In the past, they merely said that, "The experts say compliance with this new code will result in safe buildings." Now they may have to explain why "a few fatalities" are acceptable.

5.3 HOW IS THE SYSTEM ENFORCED?

Documentation of compliance with prescriptive requirements can be as simple as a list of building features. Under a performance code the engineering analysis which demonstrates compliance must become part of the building's records. Modifications to the building must be shown not to compromise the ability to meet the code's objectives, and assumptions made in the engineering analysis must be preserved.

In fact, the engineering analysis in effect becomes the code to which the building is built. If in the future there is a fire, the analysis would be examined to determine if the building was "code compliant" at the time of the fire. Variations with assumptions in the analysis would be code violations in the same way that variations with the prescriptive code are.

[††]For the National Fire Protection Association this is the Standards Council. For the Model Codes organizations they are referred to as the Code Committees.

A complication is the fact that a city's review and acceptance of an engineering analysis which may assume a certain level of service from the fire department and subsequent issuance of a permit on that basis, does not imply a contract with the building owner to provide these services in perpetuity. Governments are allowed the legal right to "change the rules" as they see fit; tax codes, social security and welfare benefits, and building codes can all be changed unilaterally and retroactively[5]. Designers and building owners who counted on the fire service to provide a certain level of service may be required to provide additional protection later, to compensate for a reduction in fire department services. This may mean that, for example, an engineering analysis should discount fire department intervention to remain conservative in the long run.

6. ESTABLISHING CLEAR OBJECTIVES

In light of the degree of international work in this area, it is timely to begin the process of establishing objectives for U.S. performance codes. This will require that the existing, national codes committees be polled to document their positions. From there, the consensus process can be used to establish a set of National goals.

The set of questions presented at the end of this paper is a starting point for this discussion. These questions have been formulated in a check-off format to facilitate the compilation of the responses across many responding groups. It is crucial that all affected groups be given an opportunity to have their opinions heard at this early stage. Traditionally, the fire service has not participated in this process except for those with regulatory responsibilities (the Fire Marshals). The fire service in Australia recently complained that they were not given such an opportunity to insure that their needs were met as that country moves toward a performance code. In the United Kingdom, Graham Butler (Assistant Chief Officer, Tyne and Wear Metropolitan Fire Brigade) observed,

> *"When the fire service arrives at a burning building they assume certain factors and performance which have an impact on their safety during suppression operations. If the fire service does not make these assumptions explicit so that they can be incorporated into performance codes, we have no assurances that these will continue to be in evidence in future buildings."*

It is further hoped that this same process can be extended to other nations undergoing such change, through the work being performed on Fire Safety Engineering in CIB W14 and the International Standards Organization (ISO) committee TC92/SC4. By doing so, we can assure that the transition to performance codes will facilitate open international trade in building design and construction by eliminating arbitrary, prescriptive requirements and replacing them with sound performance requirements supported by a common analytical methodology.

7. NIST'S ROLE

The role of the National Institute of Standards and Technology (NIST) in the promulgation of codes and standards has always been one of technical support. Historically, this support has come largely through the development of test methods and staff participation in the consensus process. More recently, NIST has been at the center of the development of fire safety engineering principles and practices which underpin the new performance methods. NIST has also tried to provide a U.S. focus in international performance code development.

In this capacity, NIST has an interest in facilitating the debate on the public policy issues presented in this paper so that the research and development on the supporting engineering methods can address the needs of the codes process into the future. As the developer of key parts of the engineering methods used, NIST provides assistance in the education of designers, engineers, and regulators in the proper application of these techniques. Thus NIST is working with fire safety educators and professional societies in developing educational resources.

8. REFERENCES

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2. Bukowski, R.W. and Tanaka, T., Towards the Goal of a Performance Fire Code, *Fire and Materials*, **15**, 175-180, 1991.

3. Buchanan, A. Fire Engineering for a Performance Based Code, Proceedings of the 6th International Fire Conference, INTERFLAM '93, C. Franks, editor, Interscience Communications Ltd, London, 457-468, 1993.

4. Fleming, Joseph F., Fire Marshal, Boston Fire Department, private communication

5. Brannigan J.D., V.M., Univ. of MD, Dept. of Fire Protection Engineering, is an attorney specializing in the legal aspects of fire safety practice.

Given that the general objectives of a performance-based fire code fall into the categories:

1. Provide life safety, and
2. Limit loss of property,

please answer the following questions.

1. Should the objectives include anything else (such as prevention of fire ignitions)? If yes, please list them.

2. **Provide life safety**: (check all that apply)

G Provide life safety means to design the building to save persons *intimate with the ignition* (e.g., clothing fires, furniture fires where the person is lying on the item ignited).

G Provide life safety means to design the building to save persons who are *incapable of self-preservation*, requiring rescue or at least assistance by others, or "protected-in-place."

G Provide life safety means to design the building to save persons within the room of fire origin but not otherwise intimate with the ignition or incapable of self-preservation.

G Provide life safety means to design the building to save persons outside the room of fire origin who are *incapable of self-preservation*, requiring rescue or at least assistance by others, or "protected-in-place."

G Provide life safety means to design the building to protect the fire service or other emergency personnel who must enter the building to affect rescues of occupants.

G Provide life safety means to design the building to protect the fire service or other emergency personnel who enter the building to fight the fire and preserve property, after all occupants have evacuated.

G Provide life safety means that any of these persons described above will not be killed but some may suffer major (permanently disabling) injuries.

G Provide life safety means that any of these persons described above will not be killed but may suffer minor injuries.

G Provide life safety means that any building occupant has a right to a protected means of egress which will prevent ANY exposure to heat, smoke or fire gases during their evacuation.

G Provide life safety means that any building occupant has a right to a protected means of egress in which they might be exposed to small quantities of heat, smoke or fire gases during their evacuation as long as these exposures do not cause injury.

G Provide life safety means that any building occupant who is *incapable of self-preservation* has a right to a *area of refuge* in which to await rescue without ANY exposure to heat, smoke or fire gases.

G Since there is generally no public outcry, society is willing to accept the current level of fire deaths, injuries, and property losses as long as the majority of life loss remains in the home.

G The risk of a fire which can result in 10 fatalities should be about 1/10 of the risk of a single fatality incident.

Do any of the above responses change as a function of occupancy? For example, should the codes allow a higher risk in the home, lower in a hotel, and lowest in a health care facility? Should educational properties be safer than mercantile? (if yes, please explain)

2. **Limit loss of Property**: (check all that apply)

G The codes should be concerned only with direct losses associated with fires.

G The codes should be concerned with indirect losses such as the effects of loss of jobs or lost tax revenue on the economy.

G The codes should be concerned with the environmental impacts (such as toxic fire products released into the air or runoff of contaminated firefighting water) of fires.

G The codes should not be concerned with preserving property belonging to the person having the fire, since this should be between that person and his/her insurance company.

G Limitation of property loss applies only to the building in which the fire occurs.

G The decision NOT to protect property should be allowed if the cost of protection exceeds its value.

Do any of the above responses change as a function of occupancy? (if yes, please explain)